Product-Chemical Profile for

Paint and Varnish Strippers and Graffiti Removers Containing 1-Methyl-2-pyrrolidone (NMP)

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SAFER CONSUMER PRODUCTS

Department of Toxic Substances Control

CalEPA California Environmental Protection Agency

CONTENTS

ABOUT THIS PROFILE

The Department of Toxic Substances Control (DTSC) identifies product-chemical combinations for consideration as Priority Products in accordance with the process identified in Article 3 of the Safer Consumer Products (SCP) regulations.[1] Based on the findings presented in this Product-Chemical Profile (Profile), DTSC finds that paint and varnish strippers and graffiti removers that contain N-Methylpyrrolidone (NMP) meet the key prioritization criteria[2] for listing a Priority Product:

1. there must be potential public and/or aquatic, avian, or terrestrial animal or plant organism exposure to the Candidate Chemical(s) in the product; and
2. there must be the potential for one or more exposures to contribute to or cause significant or widespread adverse impacts.

This Profile explains DTSC's rationale for considering a product-chemical combination prior to initiating a Priority Product rulemaking. It does not provide a comprehensive assessment of all available adverse impact and exposure literature on NMP or paint and varnish strippers and graffiti removers. DTSC will finalize this Profile after considering public comments, and may then start the rulemaking process. If this Priority Product regulation is adopted, the responsible entities must follow the reporting requirements pursuant to the SCP regulations.[3]

Readers should consider the following:

CANDIDATE CHEMICAL:
A chemical that exhibits a hazard trait and is listed on one or more authoritative lists in the SCP regulations.

PRODUCT-CHEMICAL PROFILE:
A report generated by DTSC to explain its determination that a proposed Priority Product meets the SCP regulatory criteria for potential significant or widespread adverse impacts to humans or the environment.

PRIORITY PRODUCT:
A product-chemical combination as identified in regulation by DTSC that has the potential to contribute to significant or widespread adverse impacts to humans or the environment.

1. This Profile is not a regulatory document and does not impose any regulatory requirements.
2. The Profile summarizes information compiled by DTSC as of May 24, 2018.
3. DTSC requests that stakeholders provide data on the chemical and product described in this document to assist us in the discernment process that may lead to our regulatory proposal. Written comments can be submitted using our information management system, CalSAFER,[4] prior to October 1, 2018.
4. By proposing to list this product-chemical combination as a Priority Product containing a Chemical of Concern, DTSC is not asserting that the product cannot be used safely. The proposal indicates only that there is a potential for exposure of people or the environment to the Chemical of Concern in the Priority

[1] CAL. CODE REGS. tit. 22, Division 4.5, Chapter 55, Article 3: Process for Identifying and Prioritizing Product-Chemical Combinations
[2] CAL. CODE REGS. tit. 22, § 69503.2(a)
[3] CAL. CODE REGS. tit. 22, § 69503.7 and Article 5 (Alternatives Analysis)
[4] https://calsafer.dtsc.ca.gov/

Product; that such exposure has the potential to cause or contribute to significant or widespread adverse impacts; and that safer alternatives should be explored.

SUMMARY OF THE RATIONALE FOR PRODUCT-CHEMICAL SELECTION

The Department of Toxic Substances Control (DTSC) has determined that the use of paint and varnish strippers and graffiti removers containing N-methylpyrrolidone (NMP) has the potential to expose consumers and workers to NMP, and that these exposures have the potential to cause significant or widespread adverse impacts. Therefore, DTSC is proposing that paint and varnish strippers and graffiti removers containing NMP be designated as a Priority Product.

NMP was identified as a Candidate Chemical because it appears on two of the authoritative lists identified in section 69502.2(a) of the Safer Consumer Products (SCP) regulations due to its developmental and reproductive toxicity. NMP has also been identified as an eye, skin, and possible respiratory irritant. NMP exposure can affect the central nervous system, causing symptoms similar to the effects of drinking alcohol. Various systemic effects following NMP exposure have been observed, including body weight reduction, alterations in blood chemistry, liver and kidney toxicity, neurotoxicity, and damage to the thymus. NMP may also increase the permeability of skin to other chemicals, especially organic solvents, and thereby increase the potential for exposure to other toxicants.

The primary route of NMP exposure during the use of paint and varnish strippers and graffiti removers is via absorption through the skin. However, exposure by inhalation may also be important under some circumstances, such as when these products are applied by spraying. Some kinds of personal protective equipment commonly used by consumers, such as latex gloves, do not provide adequate protection against NMP exposure. A study involving professional graffiti removers suggest that even professionals sometimes use inadequate or inappropriate personal protective equipment when working with NMP.

NMP is used in paint and varnish strippers and graffiti removers because it is an effective solvent that dissolves a broad range of coatings. Although only a relatively small fraction of the NMP imported to or produced in the U.S. is used for paint and varnish stripper or graffiti remover formulation, the U.S. Environmental Protection Agency (U.S. EPA) has determined that the use of paint and varnish strippers and graffiti removers containing NMP poses the highest potential threat of NMP exposure to consumers and workers.

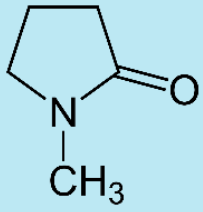
1 PRODUCT-CHEMICAL DEFINITIONS AND SCOPE

This section introduces the Candidate Chemical(s) and the product that constitute the proposed product-chemical combination.

1.1 Scope of Candidate Chemical

- NMP has been identified by the State of California as a chemical known to cause reproductive toxicity (developmental toxicity endpoint) pursuant to section 25249.8 of the Health and Safety Code. NMP was added to the Proposition 65 list of chemicals known to cause cancer or reproductive toxicity on June 15, 2001 (OEHHA 2015).
- NMP has been classified as a Category 1B reproductive toxicant by the European Commission (ECHA 2011b; European Parliament and Council 2008).

Table 1. Identification of proposed Candidate Chemical

Candidate Chemical	N-Methylpyrrolidone (NMP)
Chemical Abstracts Service Registry Number (CAS RN)	872-50-4
Synonyms	N-Methylpyrrolidone or NMP; methyl pyrrolidone; N-methyl-2-pyrrolidone; 1-methyl-2-pyrrolidone; m-pyrrole; 1-methylpyrrolidinone; N-methyl-2-pyrrolidinone; N-methyl gamma butyrolactam; 1-methyl azacyclopentan-2-one; M-pyrol; N-methyl-alpha-pyrrolidinone
Molecular formula	C_5H_9NO
Chemical structure	

1.2 Scope of Product

The proposed Priority Product comprises paint and varnish strippers and graffiti removers containing NMP (hereafter collectively referred to as "paint strippers containing NMP"). The scope of the product that DTSC is considering for listing as a Priority Product includes any product that may be marketed, sold, or described as a chemical substance or formulation designed to break down paint or varnish to facilitate its complete removal from a surface, or, in the case of graffiti removers, to remove any unwanted markings or vandalism-related markings from any surface without damaging the underlying finished surface. Such products may be designed for indoor or outdoor use in both household and institutional settings, and can be used to remove varnish, paint, and other coatings or markings from any surface. This product description is based on the product's known modes of use and on the California Air Resources Board's existing definitions of paint strippers and graffiti removers.[5] Note that graffiti removers may be designed to remove paint, but may also be designed to remove ink, marker, crayon, lipstick, nail polish, or shoe polish from a variety of non-cloth or non-fabric substrates. While paint and varnish strippers are designed to strip coatings from any surface, graffiti removers work by penetrating and dissolving unwanted graffiti and/or markings from a surface, while doing little to no damage to the underlying finished surface. Graffiti removers can be unique

[5] CAL. CODE REGS tit. 17, §§ 94508(a)(64) & 94508(a)(98)

products that may not necessarily include paint or varnish removers and strippers. However, for the purpose of this draft Profile, graffiti removers are included in the proposed product category along with paint and varnish strippers because of their similar mode of use and similar potential for NMP exposure during use.

1.3 Chemical and Product Use and Trends

NMP is a high production volume chemical. According to U.S. EPA, 184.7 million pounds of NMP were produced in or imported into the U.S. in 2012 (U.S. EPA 2015b). According to U.S. EPA, NMP is an effective solvent that, in addition to paint stripping, has uses in petrochemical processing, plastics engineering, agriculture, and electronics and industrial cleaning (U.S. EPA 2015b). NMP was produced or imported by 12 facilities in the U.S. as of 2006 (U.S. EPA 2015a). Approximately 9 percent of the NMP made in, or imported into, the U.S. is used in paint and varnish stripper and graffiti remover formulations. As of February 1, 2017, the National Institutes of Health Household Products Database lists several consumer paint stripping products that contain NMP, and paint stripping products are widely available for purchase by consumers in California (Joe et al. 2013; NIH 2015a). The U.S. EPA has determined that paint strippers and graffiti removers pose the highest potential threat of NMP exposure to consumers and workers (U.S. EPA 2015b). U.S. EPA has identified the following industries as the most likely to include paint stripping activities (U.S. EPA 2015b):

- Professional contracting
- Bathtub refinishing
- Automotive refinishing
- Furniture refinishing
- Art restoration and conservation
- Aircraft paint stripping
- Ship paint stripping
- Graffiti removal

In paint and varnish stripping or graffiti removal, the stripping product may be applied by spraying, pouring, brushing, rolling, or wiping onto the workpiece with a rag. The product may also be used in tanks where workpieces are dipped.

2 PROPERTIES AND POTENTIAL ADVERSE IMPACTS OF THE CANDIDATE CHEMICAL AND RELATED CHEMICALS

2.1 Physicochemical Properties

Reference: CAL. CODE REGS. tit. 22, § 69503.3(a)(1)(D).

Physicochemical properties can be helpful in predicting a chemical's behavior. A chemical's behavior in humans, wildlife, ecosystems, and the environment may indicate potential adverse public health and environmental impacts.

Physicochemical properties:

- Molecular weight 99.13 (ECHA 2011c)
- Colorless or light yellow liquid with an amine odor (Chemspider 2014)
- Specific gravity 1.03 (ECHA 2011c)
- Melting point -24°C (ECHA 2011c)
- Flash point 91°C (ECHA 2011c)
- Boiling point 204°C (ECHA 2011c).
- Predicted Log K_{ow} -0.38 @ 25°C (ECHA 2011c)
- Water solubility estimate from Log K_{ow} 2.483 X 105 mg/L @ 25°C (Chemspider 2014)
- Predicted vapor pressure ~0.3 mm Hg @ 25°C (Chemspider 2014)
- Predicted bioconcentration factor 0.16; the potential for bioconcentration in aquatic organisms is low (Howard 1997)

NMP's low Log K_{ow} and bioconcentration factors suggest that it is not likely to bioaccumulate. The low vapor pressure and melting points, and high boiling point, suggest that NMP will exist predominantly as a liquid at room temperature and pressure and, therefore will generally not pose an inhalation exposure risk (except in instances where it may be applied by spraying). The DFG German Research Foundation has stated that aerosol formation may be more likely with increasing NMP concentrations, temperature, and humidity (Deutsche Forschungsgemeinschaft 2006).

2.2 Environmental Fate and Transport

2.2.1 Environmental fate

Reference: CAL. CODE REGS. tit. 22, § 69503.3(a)(1)(E).

Environmental fate describes a chemical's mobility in environmental media, transformation (physical, chemical, or biological), or accumulation in the environment or biota. A chemical's environmental fate in air, water, soil, and living organisms relates to its exposure potential hazard traits, as defined in the California Code of Regulations, Title 22, Chapter 54.

NMP is expected to have a relatively short half-life in environmental media:

- **Atmosphere**
  NMP is degraded in the atmosphere by reaction with photochemically produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 5.2 hours (Howard 1997; Turi 1996). NMP's high miscibility in water suggests that it will undergo atmospheric removal by wet deposition processes (Howard 1997).
- **Water**
  NMP is completely miscible in water (NIH 2015b; U.S. EPA 1998). If released into water, NMP is not expected to adsorb to suspended solids and sediment (Howard 1997). NMP is not expected to significantly volatilize from water to the atmosphere (Howard 1997). Studies suggest that if NMP is released to water it will biodegrade under aerobic conditions with a short lag period (Howard 1997).
- **Land/soil**
  If released to soil, NMP has the potential to biodegrade under aerobic conditions (Howard 1997). NMP is highly mobile in wet or moist soils (Howard 1997; U.S. EPA 1998). Volatilization from moist soil surfaces is not expected to be an important fate process (Howard 1997). NMP may slowly volatilize from dry soil (Howard 1997; U.S. EPA 1998). The half-life of NMP has been determined to be 4.0, 8.7, and 11.5 days in clay, loam, and sandy soils, respectively (U.S. EPA 1998).

2.2.2 Other harmful chemicals generated from the Candidate Chemical

Reference: CAL. CODE REGS. tit. 22, § 69503.3(a)(1)(G).

A Candidate Chemical may degrade, form reaction products, or metabolize into other chemicals that have one or more hazard traits. These metabolites, degradation products, and reaction products (which may or may not be Candidate Chemicals) may cause different adverse impacts from those of the parent chemical. In some cases, a Candidate Chemical's degradation or reaction products or metabolites may have the same hazard trait, and may be more potent or more environmentally persistent, or both, than the parent chemical. In such cases, adverse impacts may be more severe, or may continue long after the Candidate Chemical's release to the environment.

DTSC is not basing its proposal on this factor.

2.3 Hazard Traits and/or Environmental or Toxicological Endpoints

Reference: CAL. CODE REGS. tit. 22, § 69503.3(a)(1)(A).

The hazard traits and environmental or toxicological endpoints summarized in this section are defined in the SCP regulations sections 69501.1(a)(36) and (33), respectively, both of which refer to the Office of Environmental Health Hazard Assessment's (OEHHA) Green Chemistry Hazard Trait regulations (California Code of Regulations, Title 22, Chapter 54).[6] These include exposure potential, toxicological, and environmental hazard traits.

6 https://govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=I6E0E45C032A411E186A4EF11E7983D17&originationContext=documenttoc&transitionType=Default&contextData=%28sc.Default%29

2.3.1 Developmental and reproductive toxicity

NMP's designation as a reproductive and developmental toxicant by certain authoritative bodies served as the basis for DTSC's identification of NMP as a Candidate Chemical:[7]

- NMP was added as a reproductive toxicant (developmental toxicity endpoint) to the Proposition 65 list of chemicals on June 15, 2001 (OEHHA 2015);[8]
- NMP has been recognized as a Category 1B reproductive toxicant by the European Commission (ECHA 2011b; European Parliament and Council 2008).

The maximum allowable dose level for NMP is 3,200 micrograms/day (µg/d) for the inhalation exposure route and 17,000/µg day for the dermal exposure route (OEHHA 2003). In 2015 U.S. EPA published a risk assessment for paint strippers containing NMP (U.S. EPA 2015b). U.S. EPA noted that reproductive effects as reported in the literature are widely variable in endpoint, occurrence, and dose ranges, and very difficult to interpret (Lee et al. 1987; Malek et al. 1997; Malley et al. 2001; Saillenfait et al. 2003; Sitarek and Stetkiewicz 2008; U.S. EPA 2015b). On the other hand, nearly every study that examined developmental toxicity identified some type of adverse effect resulting from NMP exposure, and these adverse effects were observed within a comparable dose range (Becci et al. 1982; Hass et al. 1995; Hass et al. 1994; Saillenfait et al. 2002; Saillenfait et al. 2003; Sitarek et al. 2012; U.S. EPA 2015b). Most of these developmental toxicicity studies used rats as model organisms and involved the oral exposure route, although some relied on inhalation exposure and one was based on dermal exposure. The endpoints consistently observed included decreased fetal/pup weight, increased fetal/pup mortality, skeletal malformations, and incomplete skeletal ossification. Fetal mortality may result from a single NMP exposure at a critical time during development (Davis et al. 2009).

U.S. EPA's risk assessment report concludes that the occurrence of reproductive effects after NMP exposure is significantly less frequent than that of developmental effects, and notes that reproductive toxicity findings are more difficult to interpret than developmental effects due to wide-ranging effect levels and a lack of consistent observations. The report also finds the available data supporting NMP's developmental toxicity to be more relevant, consistent, and sensitive than the data available for reproductive toxicity (U.S. EPA 2015b). In particular, the data suggest that fetal mortality increases at relatively low exposures, suggesting this is an especially sensitive developmental toxicity endpoint. It is not clear if the fetus is the target of NMP or if fetal effects are secondary to maternal effects, but NMP can cross the placenta (RIVM 2013). DTSC has reviewed the research relied upon by U.S. EPA and concurs with the U.S. EPA determination that developmental toxicity is a more definitively established endpoint than reproductive toxicity. The studies that U.S. EPA relied upon in establishing developmental toxicity were appropriately designed and incorporated appropriate quality controls, and the observations of different researchers corroborate the conclusion that NMP exhibits developmental toxicity. Although reproductive toxicity is less well-established than developmental toxicity, the available evidence is sufficient to suggest that there is a *potential* for NMP to be a reproductive toxicant. DTSC has concluded that the available evidence for developmental toxicity is "strong evidence" and the available evidence

[7] CAL. CODE REGS tit. 22, § 69502 et seq.

[8] The California Department of Public Health has also issued a health hazard advisory for NMP stating that NMP harms the fetus when tested in pregnant animals and is toxic to the reproductive system in both male and female animals CDPH (2014) California Department of Public Health. N-Methylpyrrolidone (NMP) Health Advisory. In: Health CDoP (ed).

for reproductive toxicity is "suggestive evidence" pursuant to the California Code of Regulations, title 22, sections 69402.6(a) and 69402.6(b)(5), respectively.

Although the potential adverse effects of NMP have not been tested directly on humans, a case of still-birth following occupational exposure to NMP has been documented (Solomon et al. 1996). This report suggested that NMP may have had a direct role in fetal toxicity. However, U.S. EPA evaluated this report and determined that the worker involved was also exposed to a variety of other solvents and that the respective exposure levels were unknown (U.S. EPA 2015b). Thus, while the report may provide some evidence of NMP fetotoxicity, the lack of quantitative exposure data precluded further consideration of the study in the U.S. EPA risk assessment.

Strong evidence for **DEVELOPMENTAL TOXICITY** essentially means any of several designated regulatory or authoritative entities has recognized the substance as exhibiting developmental toxicity.

Suggestive evidence for **REPRODUCTIVE TOXICITY** generally means the substance is suspected of having reproductive toxicity based on any of a number of factors.

- *22 CCR § 69402.4. Evidence for Developmental Toxicity Hazard Trait*
- *22 CCR § 69402.6. Evidence for Reproductive Toxicity Hazard Trait*

2.3.2 Other hazard traits

2.3.1. Ocular toxicity

NMP has been classified as a Category 2 eye irritant by the European Commission (European Parliament and Council 2008). The California Department of Public Health (CDPH) has stated that exposure to NMP may irritate the eyes (CDPH 2014). Taken together these comprise "strong evidence" for ocular toxicity pursuant to the California Code of Regulations, title 22, sections 69403.13 and 69403.17.

2.3.2. Dermatotoxicity

NMP has been classified a Category 2 skin irritant by the European Commission (European Parliament and Council 2008). CDPH has stated that exposure to NMP may irritate the skin (CDPH 2014).

2.3.3. Neurotoxicity

CDPH has stated that exposure to NMP can affect the central nervous system or brain, causing symptoms of drunkenness similar to the effects of drinking alcohol. Repeated exposure to NMP over a period of months or years may have long-lasting and possibly permanent adverse impacts on the nervous system, including fatigue, sleeplessness, poor coordination, difficulty concentrating, loss of short-term memory, and personality changes. (CDPH 2014)

2.3.4. Systemic Effects

Systemic effects of NMP have been identified after repeated oral dosing in test animals. The observed effects include body weight reduction, foot splay, alterations in blood chemistry, liver and kidney toxicity, neurotoxicity, and thymic atrophy (RIVM 2013; U.S. EPA 2015b; WHO 2001). CDPH has stated that NMP may irritate the nose

and throat (CDPH 2014). A whole-body inhalation study identified effects such as bone marrow hypoplasia, testicular lesions, necrosis of lymphoid tissue, and, at the highest dose, mortality (RIVM 2013).

2.4 Populations That May Be Harmed by the Candidate Chemical

2.4.1 Human populations and nonhuman organisms that may experience adverse impacts from exposure to the Candidate Chemical

Reference: CAL. CODE REGS. tit. 22, § 69503.3(a)(1)(F).

This section identifies specific populations of humans and environmental organisms that may be harmed if exposed to the Candidate Chemical, based on the hazard traits identified in Section 2.3 and the type of exposures (e.g., single, intermittent, or chronic).

Human fetuses may be especially vulnerable to the adverse impacts of NMP. In its 2015 risk assessment for NMP in paint strippers, U.S. EPA focused on reduced fetal body weight in animal studies as the basis of the dose-response analysis for ***chronic*** exposures (U.S. EPA 2015b). It was noted that reduced fetal body weight is considered a marker for fetal growth restriction, which is assumed to be representative of chronic exposures (U.S. EPA 2015b; Van Raaij et al. 2003). U.S. EPA focused on fetal resorptions and mortality as the basis of the dose-response analysis for ***acute*** exposures because such outcomes may result from a single exposure at a developmentally critical period (Davis et al. 2009; U.S. EPA 2015b; Van Raaij et al. 2003). U.S. EPA concluded that adverse developmental outcomes can arise from both chronic and acute exposures during critical windows of prenatal development at any time during pregnancy, and can result in persistent chronic adverse impacts to the developing fetus. Thus, NMP appears to have the potential to cause adverse developmental outcomes in humans from a single exposure or from multiple exposures over time.

2.4.2 Sensitive subpopulations, species, or environments that have the potential for adverse impacts from exposure to the Candidate Chemical

Reference: CAL. CODE REGS. tit. 22, §§ 69503.3(a)(1)(F) and 69503.3(a)(2).

Sensitive subpopulations, environmentally sensitive habitats, endangered and threatened species, and impaired environments have special consideration as they may be more vulnerable than the general population.

As noted above in Section 2.4.1, women of childbearing age, pregnant women, and their fetuses may be especially at risk of adverse impacts from exposure to NMP. Paint stripping was identified as being of specific concern because of the high potential for exposure to NMP during the use of paint strippers.

3 FACTORS RELATED TO POTENTIAL EXPOSURE TO THE CANDIDATE CHEMICAL IN THE PRIORITY PRODUCT

This section summarizes significant findings related to the exposure factors that are relevant to this product-chemical combination because they may contribute to or cause significant or widespread adverse impacts. Further clarification of each exposure factor is included below.

3.1 Presence and Use Patterns of the Product

3.1.1 Market presence of the product

Reference: CAL. CODE REGS. tit. 22, §§ 69503.3(b)(1)(A) and (B).

Product market presence information may be used as a surrogate to assess potential exposures to the Candidate Chemical in the product. This information may include statewide sales by volume, the number of units sold or amount of sales generated, or information on the targeted customer base.

DTSC was unable to find data for the amount of NMP-containing paint strippers sold in California. However, a survey published in 2013 confirms that paint strippers are widely available for retail purchase by consumers in the state (Joe et al. 2013).[9] While this survey shows that methylene chloride-based formulations are the most common, paint strippers containing alternatives to methylene chloride, including NMP, are also widely available. CDPH has identified a number of specific paint stripping products containing NMP that are sold in California (CDPH 2013; CDPH 2014).

As noted previously, NMP is a high production volume chemical. According to U.S. EPA, 184.7 million pounds of NMP were produced or imported into the U.S. in 2012 (EPA 2015a). It has been estimated that approximately 9 percent of this NMP (approximately 16.6 million pounds) is used in paint stripper and graffiti remover formulations annually (EPA 2015a). The National Institutes of Health Household Products Database identifies a number of paint stripping products and graffiti removers that contain NMP in concentrations ranging from 9 percent to 70 percent (NIH 2015). U.S. EPA reported that some high-end stripping products contain 100 percent NMP (U.S. EPA 2015b).

3.1.2 Intended use of the product

Reference: CAL. CODE REGS. tit. 22, §§ 69503.3(b)(1)(C) and 69503.3(b)(4)(D)1.

Potential exposures can also be inferred by assessing how a product is typically used, the typical useful life (i.e., replacement frequency) of durable products, the typical rate of consumption of consumable products, the frequency of use, and the typical quantity consumed per use. The SCP regulations give special consideration to household and recreational use.

[9] This survey focused on paint strippers that contain methylene chloride and does not report the number of paint strippers available that are formulated with NMP.

Consumers may use paint strippers to strip coatings or graffiti from a wide variety of items. Paint stripper is also used in industry. U.S. EPA used U.S. Census data to estimate the average number of employees per facility where NMP paint strippers may be used, and these data provide insight into potential commercial uses (U.S. EPA 2015b):

- Professional contracting (likely to include bathtub refinishing): 5 workers/facility
- Automotive refinishing: 6 workers/facility
- Furniture refinishing: 3 workers/facility
- Art restoration and conservation (not estimated)
- Aircraft paint stripping: 320 workers/facility (for aircraft manufacturing only)
- Ship paint stripping: 100 workers/facility
- Graffiti removal: 8 workers/facility

3.1.3 Household and workplace presence of this and other products containing the Candidate Chemical, and aggregate effects

Reference: CAL. CODE REGS. tit. 22, §§ 69503.3(a)(1)(B) and *69503.3(b)(3).*

The potential for exposure to the Candidate Chemical in the product relates to how common the product is in households and workplaces. The household and workplace presence of other products that contain the same Candidate Chemical may increase the potential for aggregate effects.

NMP is an effective solvent used in a number of different types of products, so the potential exists for aggregate exposure from multiple products. According to the National Institutes of Health Household Products Database, NMP is used in a variety of pesticides, automotive products, general purpose cleaners, and home maintenance products (NIH 2015a). Concentrations in these other products reportedly range from barely detectable up to 100 percent. DTSC has not identified any data that would allow us to evaluate the contribution or potential contribution to aggregate NMP exposure from all of these sources, or how that may relate to potential exposures from paint strippers. Although paint strippers account for only about 9 percent of NMP use, the potential for NMP exposure during the use of paint stripping products is especially high (U.S. EPA 2015b). U.S. EPA has identified duration of use and concentration of NMP in the product as important drivers of exposure risk.

In California there are approximately 80 businesses that use relatively large quantities of paint or varnish stripper (Morris and Wolf 2006). Approximately 500 additional facilities, such as antique shops, do some stripping as part of their business (Morris and Wolf 2006). DTSC has been unable to determine the percentage of these businesses using paint strippers that contain NMP as opposed to other active ingredients, such as methylene chloride. While the number of workers in these facilities is not known, these observations suggest that there is a potential for a significant number of workers to use paint strippers with NMP.

U.S. EPA recently tried to estimate the number of workers potentially exposed to NMP in paint strippers, but was unable to do so due to a lack of relevant data (EPA 2015a). However, estimates of the number of workers potentially exposed to methylene chloride during paint stripping may provide some perspective. U.S. EPA previously estimated that over 230,000 workers at 13,500 facilities in the U.S. are directly exposed to methylene

chloride during paint stripping operations (EPA 2015a). Since methylene chloride is more widely used as a paint stripper than NMP, U.S. EPA concluded that fewer than 230,000 workers nationwide are likely to be exposed to NMP during paint stripping operations, but the agency was unable to provide an actual estimate because of a lack of data regarding industrial use. U.S. EPA also was not able not estimate the number of consumers that may be exposed to NMP in paint strippers due to a lack of data.

3.2 Potentially Exposed Populations and Product-Use Scenarios

3.2.1 Targeted customer base

Reference: CAL. CODE REGS. tit. 22, § 69503.3(b)(1).

Paint strippers are readily available to the public at hardware stores, home improvement stores, and various other types of retailers. A variety of businesses also may use paint strippers. Targeted customers include any homeowners and businesses with a desire to strip paint or varnish, or to remove graffiti from private property, and government maintenance and janitorial workers that remove graffiti from public property. Although the amount of paint stripper containing NMP that is offered for sale in California is not known, paint strippers and graffiti removers containing NMP are generally available for purchase by businesses and consumers.

3.2.2 Use scenarios that may contribute to adverse impacts

Reference: CAL. CODE REGS. tit. 22, § 69503.3(b)(4)(D).

The SCP regulations consider a variety of uses that may contribute to the exposure to the product-chemical combination. These include household and recreational use, use by sensitive subpopulations, and use by workers, customers, clients, and members of the general public in homes, schools, workplaces, or other locations.

U.S. EPA has concluded that although paint strippers represent only about 9 percent of NMP use, the potential for NMP exposure to users of these products is especially high (U.S. EPA 2015b). The person directly involved in the use of paint stripper containing NMP is at the greatest risk of exposure; no dermal or inhalation exposure risk was identified for people in close proximity to, but not directly engaged in, NMP paint stripper use. The concentration of NMP in the paint stripper and the duration of paint stripper use are key factors in determining the magnitude of NMP exposure. DTSC was unable to find any data regarding the average duration of paint stripper use by consumers and professionals. The duration of paint stripper use is expected to vary widely depending on the concentration of NMP in the paint stripper, the type of surface coating being stripped, the type of object from which the coating is being removed, and environmental conditions during the stripping process.

NMP paint and varnish strippers and graffiti removers may be applied by pouring, wiping, painting, rolling, or spraying onto the work surface, or by dipping workpieces into a tank containing stripper. Exposure potential may also be affected dramatically by the application method used and by the use of personal protective equipment. Based on available evidence, DTSC agrees with U.S. EPA that the potential for exposure to NMP is greatest for workers and consumers who directly engage in the use of paint strippers without the use of appropriate personal protective equipment, and that there is likely little to no exposure risk for bystanders who are not directly engaged in paint stripper use.

3.3 Exposures to the Candidate Chemical Throughout the Product Life Cycle

3.3.1 Indicators of potential exposures to the Candidate Chemical from the product

Reference: CAL. CODE REGS. tit. 22, § 69503.3(b)(2).

The SCP regulations consider various data that indicate potential for exposure to the Candidate Chemical or its degradation products, including: (i) the Candidate Chemical's presence in and release from the product; (ii) monitoring data indicating the Candidate Chemical's presence in the indoor and outdoor environment, biota, humans (e.g., biomonitoring studies), human food, drinking water, and other media; and (iii) evidence of persistence, bioaccumulation, and lactational and transplacental transfer.

A study of solvent exposure in 38 professional graffiti removers concluded that graffiti removal products containing NMP and glycol ether were used most frequently (Anundi et al. 2000). Both breathing-zone analysis and biomonitoring were used to assess exposure. While long-term exposures were generally low and below the corresponding permissible exposure limits for the substances measured, short-term exposures were high during some work situations (i.e., in enclosed spaces and/or when spraying was involved) and often exceeded Swedish short-term occupational exposure limits. The study also noted that 50 percent of the monitored workers reported splashes on the hands, face, and body. While 87 percent of the monitored workers used gloves for protection, only 8 percent (three individuals) used gloves considered appropriate for work with organic solvents. Consumers may not be aware that commonly used gloves (e.g., latex) do not provide protection against NMP exposure, and the graffiti worker study suggests that even professionals do not always choose the correct personal protective equipment for work with NMP.

In 1993 the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation during the renovation of an home in Atlanta, Georgia (NIOSH 1994). A solvent containing NMP was being used to remove paint, and the owner of a wood flooring company requested that NIOSH conduct the evaluation. NIOSH performed personal breathing zone and area air sampling during use of this solvent. Sampling found detectable levels of NMP during the stripping process, suggesting that worker exposure was likely. NIOSH noted that the potential health hazards associated with the exposures were unclear at the time this assessment was conducted. The assessment also noted that personal protective equipment was not routinely used by the workers.

3.3.2 Potential exposure to the Candidate Chemical during the product's life cycle

Reference: CAL. CODE REGS. tit. 22, § 69503.3(b)(4)(A).

Potential exposures to the Candidate Chemical or its degradation products may occur during various product life cycle stages, including manufacturing, use, storage, transportation, waste, and end-of-life management practices. Information on existing regulatory restrictions, product warnings, or other product-use precautions designed to reduce potential exposures during the product's life cycle may also be discussed here.

U.S. EPA also evaluated NMP uses in 1998 and concluded that workers who use paint strippers with NMP or consumers who use paint stripping products containing NMP at home are at greatest risk of exposure (EPA 1998). NMP is well-absorbed following dermal exposures, and dermal absorption is the primary exposure

pathway in humans (Bader et al. 2008; EPA 2015a; Keener et al. 2007; EPA 1998). Although NMP is not especially volatile, there is also a potential for inhalation exposure when products containing NMP are used in poorly ventilated areas or are applied by spraying (EPA 1998). In its more recent risk assessment, U.S. EPA determined that elevated exposure risk applies only to people directly engaged in the use of paint strippers containing NMP; paint strippers containing NMP are not expected to pose exposure risk to people not directly engaged in their use (EPA 2015a).

The European Chemicals Agency (ECHA) has concluded that some types of stripping operations, particularly manual operations, could lead to significant dermal exposure in the absence of appropriate personal protective equipment (ECHA 2011a). Commonly used types of gloves may not provide adequate protection against dermal exposure to NMP (EPA 1998). U.S. EPA recommends that only butyl-rubber gloves should be used to protect against NMP exposure. In more recent work, U.S. EPA found that a significant risk of exposure was associated with the use of NMP-containing paint strippers for more than four hours per day, for both acute and chronic use scenarios; these exposure risks were not mitigated by use of personal protective equipment such as respirators or gloves (EPA 2015a).

Diluting NMP in water seems to reduce the dermal absorption of NMP (Keener et al. 2007; Payan et al. 2003). Prolonged exposure to pure NMP can increase the permeability of skin, allowing for increased toxicant uptake from the environment (RIVM 2013). Thus, there is the potential for other chemicals, especially organic solvents, to increase the exposure potential for NMP, and there is the potential for NMP exposure to increase the potential for exposure to other toxicants.

3.3.3 Frequency, extent, level, and duration of potential exposure for each use and end-of-life scenario

Reference: CAL. CODE REGS. tit. 22, § 69503.3(b)(4)(E).

Frequency of product use (how often) and the extent (the number of routes of exposure), level (concentration of the Candidate Chemical), and duration (length of time) of use, are all considered when assessing the potential for exposure to the Candidate Chemical or its degradation products.

DTSC did not find any data regarding the duration and extent of consumer paint stripper use. Paint and varnish strippers and graffiti removers may be applied by pouring, wiping, painting, rolling, or spraying onto the work surface, or by dipping workpieces into a tank containing stripper. Exposure potential may be affected dramatically by environmental conditions, the method used to apply paint stripper, the type of object and coating on which the paint stripper is being used, and by the use of personal protective equipment.

3.4 Factors That May Mitigate or Exacerbate Exposure to the Candidate Chemical

3.4.1 Containment of the Candidate Chemical within the product

Reference: CAL. CODE REGS. tit. 22, § 69503.3(b)(4)(F).

When assessing exposure potential, the SCP regulations consider how the Candidate Chemical is contained or bound during product use (e.g., as an inaccessible component inside a product) and the degree to which the containment is protective at end-of-life (e.g., recycling or disposal).

Paint strippers are a formulated liquid product, and NMP can be a major or predominant ingredient. While paint strippers are distributed in containers, they must be removed from the container in order to be used. While exposure to NMP may also potentially occur while paint stripper is in a closed container (due to mishandling, puncture, or deterioration, e.g.), it is more likely to occur during the use phase, while or after the product is being applied to a coated surface.

3.4.2 Engineering and administrative controls that reduce exposure concerns

Reference: CAL. CODE REGS. tit. 22, § 69503.3(b)(4)(G).

The SCP regulations also consider any administrative controls (e.g., warning labels on a product) or engineering controls (e.g., specialized ventilation equipment) that can reduce the potential for chemical exposures from the product during product manufacturing, use, or end-of-life.

The length of time that paint stripper is used, and the concentration of NMP in the paint stripping product, both appear to be important drivers of NMP exposure potential. U.S. EPA associated the use of products with relatively high NMP concentrations (i.e., above 25 percent), which are readily available to consumers, with a significant potential for NMP exposure (EPA 2015a). U.S. EPA also determined that there is a significant potential for NMP exposure associated with use of paint strippers for more than four hours per day (EPA 2015a). The potential for NMP exposure associated with the short-term use (e.g., 1-2 hour) of stripping products containing low concentrations of NMP (e.g., 25 percent or less) was lower that for longer-duration use of paint strippers containing higher concentrations of NMP.

4 ADVERSE WASTE AND END-OF-LIFE EFFECTS

Reference: CAL. CODE REGS. tit. 22, §§ 69503.2(b)(1)(B) and 69501.1(a)(8).

This section summarizes findings related to the waste materials and byproducts generated during the life cycle of the product and their associated adverse effects. The subsections below are elements in the definition of Adverse Waste and End-of-Life, as described in the SCP regulations. These considerations can form part of the basis for proposing the product-chemical combination.

U.S. EPA did not assess the environmental risk of NMP because NMP is considered to have low hazard for ecological receptors and low environmental persistence.[10] While some environmental receptors may be exposed to NMP if paint stripper is improperly disposed of, and may experience adverse impacts, DTSC believes that the probability of this occurring is very low. Therefore, DTSC is not basing the proposed listing of NMP-based paint strippers as a Priority Product on the potential for end-of-life exposures.

[10] https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-n-methylpyrrolidone-nmp#environment

5 ADDITIONAL CONSIDERATIONS

This section summarizes other relevant information not captured under the adverse impact and exposure factors named in section 69503.3 of the SCP regulations.

5.1 Data Gaps

Areas where there is data gap uncertainty include:

- General market information regarding how much paint or varnish stripper and graffiti remover containing NMP is manufactured in, used in, placed on the market in, and/or sold in California
- The number and types of consumers (e.g., workers, janitors, homeowners) who purchase and use paint stripping and graffiti removal products containing NMP in California:
    - How many consumers may purchase paint stripping products for use in their homes?
    - How many businesses in California purchase paint stripping products in California?
    - How many workers in California use paint stripping products?
    - How much graffiti remover containing NMP is sold in California?
    - Who are the consumers that purchase graffiti remover (e.g., private citizens, janitorial services, local governments)?
- The frequency and duration of product use for each of the different groups of consumers

6 DISCUSSION OF POTENTIAL FOR SIGNIFICANT AND/OR WIDESPREAD IMPACTS

This section integrates the information provided in the Profile to demonstrate how the key prioritization principles, as identified in the SCP regulations, are met.

The information presented in this report represents all of the information DTSC is relying on to substantiate the existence of potential adverse impacts and exposures from NMP in paint and varnish strippers and graffiti removers. While DTSC did not find information pertaining to every prioritization factor listed in Article 3 of the SCP regulations, DTSC has nonetheless determined, based on the information that is available, that workers and consumers may be exposed to NMP from paint and varnish strippers and graffiti removers during use, and that these exposures may contribute to or cause significant or widespread adverse impacts.

DTSC finds that the available information regarding the potential reproductive and developmental toxicity of NMP is sufficient to conclude, pursuant to the SCP regulations, that there is a potential for one or more exposures to contribute to or cause adverse developmental and/or reproductive impacts. DTSC has determined that the available evidence for developmental toxicity is "strong evidence" and the available evidence for reproductive toxicity is "suggestive evidence," pursuant to the California Code of Regulations, title 22, sections 69402.6(a) and 69402.6(b)(5), respectively.

DTSC has carefully evaluated all of the information presented in this report and determined that it constitutes "reliable information" as defined in the SCP regulations. The information we have relied upon was either generated by an appropriate authoritative body (i.e., a government body such as U.S. EPA), or was adequately peer-reviewed by qualified and disinterested parties, and is relevant for consideration in this report.[11]

[11] See CAL. CODE REGS tit. 22, § 69503.2(b)(1)(C)

7 ALTERNATIVES

Reference: CAL. CODE REGS. tit. 22, § 69503.2(b)(3).

This section summarizes information available to DTSC regarding alternatives that may or may not be safer than the Candidate Chemical. DTSC does not need to ensure that these alternatives are safer, and may summarize their associated hazards to illustrate readily available information. The sections below may include information such as how readily available an alternative is, product functions addressed by the alternative, and implications for manufacturers using the alternative (e.g., use limitations, product reformulation, different equipment needs).

Pursuant to section 69503.2(b)(3), in considering whether to list a paint strippers with NMP as a Priority Product, DTSC may consider whether there is a readily available, safer alternative. In 2011 ECHA concluded that the main available alternative to NMP was N-ethylpyrrolidone (NEP), and noted that there would be no other feasible alternative to NMP if NEP were subject to the same hazard classification as NMP (ECHA 2011a). NEP has subsequently been recognized as a category 1B reproductive toxicant in the European Union (European Commission 2013). NEP has also been added to DTSC's list of Candidate Chemicals based on reproductive toxicity.

Methylene chloride-based paint strippers comprise the largest share of the paint stripper market, and methylene chloride may substitute for NMP in some paint stripper applications. Indeed, Lyondell Chemical Co. has stated that NMP is the leading alternative to methylene chloride for paint stripping, graffiti removal, and industrial cleanup,[12] suggesting that methylene chloride may be likely a leading alternative to NMP as well. However, methylene chloride is a Candidate Chemical, and DTSC initiated rulemaking in 2017 to list paint and varnish strippers containing this chemical as a Priority Product.[13]

In 2006, the Institute for Research and Technical Assistance (IRTA) published a report for DTSC identifying low-volatility and low-toxicity alternatives to methylene chloride in paint strippers (Morris and Wolf 2006). Alternatives to methylene chloride were tested in large furniture stripping companies with automated stripping equipment, by smaller furniture stripping companies that strip by hand, by contractors who strip on-site, and by consumers who strip by hand. According to the IRTA report, the best-performing alternative paint stripping formulations contained benzyl alcohol as the active ingredient. While it was not specifically tested as an alternative to NMP, it is possible that benzyl alcohol may be an effective alternative to NMP in some paint stripper formulations.

A report prepared for the European Commission Directorate General of Enterprise and Industry identified various potential chemical and mechanical alternatives to methylene chloride for paint stripping, such as heat, sanding, and sand blasting (Tukker and Simmons 1999). Again, these were not specifically tested as alternatives to NMP, but they may be able to serve as functional substitutes for NMP-based stripping formulations in some cases.

[12] https://www.lyondellbasell.com/globalassets/documents/chemicals-technical-literature/lyondellbasell-chemicals-technicalliterature-nmp-based-paint-stripper-formulations-2283.pdf
[13] https://calsafer.dtsc.ca.gov/cms/commentpackage/?rid=12734&from=search

Subsequent to a ban on graffiti removal products containing NMP in Sweden, dipropyleneglycol monomethyl ether (DPGME) and propylene glycol monomethyl ether (PGME) have become more common in paint strippers, suggesting that DPGME and PGME may be potential alternatives to NMP for some applications (Anundi et al. 2000). PGME is on DTSC's list of Candidate Chemicals, but DPGME is not, and is generally considered to have low toxic potential (OECD 2001).

Recently, the Toxics Use Reduction Institute at the University of Massachusetts Lowell published an assessment of safer and effective alternatives to methylene chloride for paint stripping products (Morose et al. 2017). The report identifies a DMSO and methyl acetate-based stripping formulation that worked as well or nearly as well as methylene chloride-based and NMP-based paint stripping products, suggesting that alternative formulations are being developed that may hold promise as substitutes for NMP-based paint strippers.

While DTSC acknowledges that possible alternatives to the use of NMP in paint stripper exist, we are unable to evaluate the economic and technical feasibility of using such alternatives. In addition, we are unable to determine whether any of the potential alternatives are necessarily safer than NMP. Manufacturers choosing to substitute any other chemical ingredient for NMP would be required to notify DTSC pursuant to the California Code of Regulations, title 22, section 69505.2.

8 OTHER REGULATORY PROGRAMS

Reference: CAL. CODE REGS. tit. 22, § 69503.2(b)(2).

8.1 Applicable California State Laws and Regulations

- NMP is recognized as a reproductive toxicant (developmental toxicity endpoint) by the State of California, and maximum allowable dose levels have been established (OEHHA 2003). Products that result in daily exposures exceeding these maximum allowable dose levels must carry an appropriate label under California law.
- The California Division of Occupational Safety and Health has established a permissible exposure limit for NMP in air (CDPH 2014).

8.2 Applicable Federal Laws and Regulations

- NMP is on the U.S. EPA consolidated list of chemicals subject to reporting requirements under the Emergency Planning and Community Right-to-Know Act, the Comprehensive Environmental Response, Compensation, and Liability Act, and section 112(r) of the Clean Air Act.[14]
- In 2015 U.S. EPA initiated rulemaking under the federal Toxic Substances Control Act section (6)(a) to address risks associated with the use of NMP in paint strippers. A public comment period on the proposed rule closed on May 19, 2017 but U.S. EPA has not yet finalized the rule and has began taking steps to conduct a risk evaluation for NMP Frank R. Lautenberg Chemical Safety for the 21st Century Act.[15,16]

[14] http://www2.epa.gov/epcra/consolidated-list-lists (accessed March 19, 2015)
[15] https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-n-methylpyrrolidone-nmp
[16] https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/n-methylpyrrolidone-nmp-problem-formulation

ABBREVIATIONS, ACRONYMS, AND MEASUREMENTS

CDPH	California Department of Public Health
DPGME	dipropylene glycol monomethyl ether
DTSC	Department of Toxic Substances Control
ECHA	European Chemicals Agency
IRTA	Institute for Research and Technical Assistance
K_{ow}	Octanol-water partition coefficient
mg/L	Milligrams per liter
NEP	N-Ethylpyrrolidone
NIOSH	National Institute for Occupational Safety and Health
NMP	N-Methylpyrrolidone
PGME	Propylene glycol monomethyl ether
SCP	Safer Consumer Products
U.S. EPA	U.S. Environmental Protection Agency

REFERENCES

Anundi H, Langworth S, Johanson G, et al. (2000) Air and biological monitoring of solvent exposure during graffiti removal. Int Arch Occup Environ Health 73(8):561-9

Becci PJ, Knickerbocker MJ, Reagan EL, Parent RA, Burnette LW (1982) Teratogenicity study of N-methylpyrrolidone after dermal application to Sprague-Dawley rats. Fundam Appl Toxicol 2(2):73-6

CDPH (2013) California Department of Public Health. Guide to Choosing Paint Stripping Products: Safety Considerations.

CDPH (2014) California Department of Public Health. N-Methylpyrrolidone (NMP) Health Advisory. In: Health CDoP (ed).

Chemspider (2014) Royal Society of Chemistry Chemspider. In. http://www.chemspider.com/ Accessed August 14, 2014

Davis A, Gift JS, Woodall GM, Narotsky MG, Foureman GL (2009) The role of developmental toxicity studies in acute exposure assessments: analysis of single-day vs. multiple-day exposure regimens. Regul Toxicol Pharmacol 54(2):134-42 doi:10.1016/j.yrtph.2009.03.006

Deutsche Forschungsgemeinschaft (2006) The Senate Commission of the Deutsche Forschungsgemeinschaft on the Investigation of Health Hazards of Chemical Compounds in the Work Area. Maximum Allowable Concentrations (MAK).

ECHA (2011a) European Chemicals Agency. Annex XV Dossier Proposal For Identification Of A Substance As Category 1A or 1B CMR, PBT, vPvB Or A Substance Of An Equivalent Level Of Concern, N-methyl-2-pyrrolidone.

ECHA (2011b) European Chemicals Agency. Member State Committee Support Document For Identification Of 1-Methyl-2-Pyrrolidone As A Substance Of Very High Concern Becuase Of Its CMR Properties.

ECHA (2011c) European Chemicals Agency. Support Document For Identification Of 1-Methyl-2-Pyrrolidone As A Substance Of Very High Concern Because Of Its CMR Properties.

European Commission (2013) Regulation (EU) No 944/2013 of 2 October 2013 amending, for the purposes of its adaptation to technical and scientific progress, Regulation (EC) No 1272/2008 of the European Parliament and of the Council on classification, laelling and packaging of substances and mixtures. In: Commission E (ed).

European Parliament and Council (2008) Regulation (EC) No 1272/2008 of 16 December 2008. In: Council EPa (ed).

Hass U, Jakobsen BM, Lund SP (1995) Developmental toxicity of inhaled N-methylpyrrolidone in the rat. Pharmacol Toxicol 76(6):406-9

Hass U, Lund SP, Elsner J (1994) Effects of prenatal exposure to N-methylpyrrolidone on postnatal development and behavior in rats. Neurotoxicol Teratol 16(3):241-9

Howard PH (1997) Handbook of Environmental Fate and Exposure Data for Organic Chemicals, vol 5. CRC Press

Joe L, Harrison R, Shusterman D, McNary J, Krishwaswami J (2013) Dichloromethane (methylene chloride) in paint strippers: Survey of retail stores. In: Health CDoP (ed).

Lee KP, Chromey NC, Culik R, Barnes JR, Schneider PW (1987) Toxicity of N-methyl-2-pyrrolidone (NMP): teratogenic, subchronic, and two-year inhalation studies. Fundam Appl Toxicol 9(2):222-35

Malek DE, Malley LA, Slone TW, et al. (1997) Repeated dose toxicity study (28 days) in rats and mice with N-methylpyrrolidone (NMP). Drug Chem Toxicol 20(1-2):63-77 doi:10.3109/01480549709011079

Malley LA, Kennedy GL, Elliott GS, et al. (2001) Chronic toxicity and oncogenicity of N-methylpyrrolidone (NMP) in rats and mice by dietary administration. Drug Chem Toxicol 24(4):315-38 doi:10.1081/DCT-100106262

Morose G, Marshall J, McCarthy A, Harripersaud V, Giarrosso A (2017) Assessment of Safer and and Effective Alternatives to Methylene Chloride for Paint Stripping Products. Toxics Use Reduction Institute

Morris M, Wolf K (2006) Methylene Chloride Consumer Product Paint Strippers: Low-VOC, Low Toxicity Alternatives.

NIH (2015a) National Institutes of Health, Household Products Database. In. http://householdproducts.nlm.nih.gov/cgi-bin/household/brands?tbl=chem&id=171&query=N-methylpyrrolidone&searchas=TblChemicals Accessed March 9 2015

NIH (2015b) National Institutes of Health. PubChem Open Chemistry Database. In. http://pubchem.ncbi.nlm.nih.gov/compound/13387?from=summary%20-%20x351#section=Top Accessed March 9 2015

NIOSH (1994) National Institute for Occupational Safety and Health. Health Hazard Evaluation Report: NMP. NIH

OECD (2001) Organization for Economic Cooperation and Development. Dipropylene Glycol Methyl Ether.

OEHHA (2003) California Office of Environmental Health Hazard Assessment. Proposition 65 Maximum Allowable Dose Level (MADL) for Reproductive Toxicity for N-Methylpyrrolidone for Dermal Inhalation Exposures. In: Assessment COoEHH (ed).

OEHHA (2015) California Office of Environmental Health Hazard Assessment. Chemicals Known to the State to Cause Cancer or Reproductive Toxicity.

RIVM (2013) The Dutch National Institute for Public Health and the Environment. Annex XV Restriction Report: Proposal for a Restriction, N-methylpyrrolidone (NMP), Version 2.

Saillenfait AM, Gallissot F, Langonne I, Sabate JP (2002) Developmental toxicity of N-methyl-2-pyrrolidone administered orally to rats. Food Chemistry and Toxicology 40(11):1705-1712

Saillenfait AM, Gallissot F, Morel G (2003) Developmental toxicity of N-methyl-2-pyrrolidone in rats following inhalation exposure. Food Chem Toxicol 41(4):583-8

Sitarek K, Stetkiewicz J (2008) Assessment of reproductive toxicity and gonadotoxic potential of N-methyl-2-pyrrolidone in male rats. Int J Occup Med Environ Health 21(1):73-80 doi:10.2478/v10001-008-0006-z

Sitarek K, Stetkiewicz J, Wasowicz W (2012) Evaluatoin of reproductive disorders in female rats exposed to N-Methyl-2-pyrrolidone. Biochemical Journal Birth Defects Research (Part B)(95):195-201

Solomon GM, Morse EP, Garbo MJ, Milton DK (1996) Stillbirth after Occupatoinal Exposure to N-Methyl-2-Pyrrolidone: A Case Report and Review of the Literature. Journal of Occupational and Environmental Medicine 38(7):705-713

Tukker A, Simmons LP (1999) Methylene chloride: Advantages and Drawbacks of Possible Market Restrictions in the EU.

Turi MTURI (1996) N-Methyl Pyrrolidone: Chemical Profile.

U.S. EPA (1998) United States Environmental Protection Agency. Environmental Profle for N-Methylpyrrolidone.

U.S. EPA (2015a) United States Environmental Protection Agency. Non-confidential 2006 IUR Company/Chemical Records. In. http://cfpub.epa.gov/iursearch/index.cfm?err=t Accessed March 11 2015

U.S. EPA (2015b) United States Environmental Protection Agency. TSCA Workplan Chemical Risk Assessment, N-Methylpyrrolidone: Paint Stripping Use.

Van Raaij MTM, Janssen PAH, Piersma AH (2003) The relevance of developmental toxicity endpoints for acute limit setting. In: RIVM (National Institute for Public Health and the Enironment) tN (ed).

WHO (2001) World Health Organization. Concise International Chemical Assessment Document 35 N-Methyl-2-Pyrrolidone.

APPENDIX A. REPORT PREPARATION

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